Remarks

In view of the above amendments and the following remarks, reconsideration of the outstanding office action is respectfully requested.

Claims 28, 29, and 31 have been amended and claim 30 has been canceled. Support for the amendments is found in the present application at, *inter alia*, paragraphs [0046] (claims 28 and 29) and [0073] (claim 31). No new matter has been added. Claims 1–28 and 31–37 are pending.

The objection to claims 28 and 31 is respectfully traversed in view of the above amendments.

The rejection of claims 28–34 under 35 U.S.C. § 103(a) for obviousness over Seraphin, "Influence of Nanostructure Size on the Luminescence Behavior of Silicon Nanoparticles Thin Films," *J. Mater. Res.* 12(12):3386 (1997) ("Seraphin") is respectfully traversed in view of the above amendments.

Seraphin describes the effect of particle size and quantum confinement on the luminescence properties of nanoscale silicon thin films. Thins films of agglomerated silicon nanoparticles deposited onto Teflon substrates were oxidized, *inter alia*, chemically to reduce the silicon core dimensions, resulting in a shift of the luminescence emission peak to shorter wavelengths. Removal of the oxide using hydrofluoric acid ("HF") resulted in further blueshifting of the luminescence, as did subsequent reoxidation in air. A blueshift was also observed in thin films etched with a HF/nitric acid/water solution.

The position of the U.S. Patent and Trademark Office ("PTO") is that the claimed methods would have been obvious in light of Seraphin. Applicants respectfully disagree, for the reasons set forth in the accompanying Second Declaration of Mark T. Swihart, Ph.D., Under 37 C.F.R. § 1.132 ("2d Swihart Decl.") (Exhibit 1).

Regarding claims 28 and 29 of the present invention, Seraphin teaches two methods for modifying the luminescence of nanoscale silicon thin films: (1) sequential, separate exposures to HF and HNO_3, and (2) simultaneous exposure to HF and HNO_3. 2d Swihart Decl. ¶ 8. The methods of the present invention would not have been obvious from either of these approaches to one of ordinary skill in the art. *Id.*

Firstly, the solution of claim 28 is neither taught nor suggested by Seraphin. At page 3 if the outstanding office action, the PTO has cited page 3387, column 1, of Seraphin as teaching an acid etch solution of about 0.5% to 20% HF and about 10% to 40%

HNO_3. It does not. Swihart Decl. ¶ 9. Seraphin teaches etching thin films in 48% HF for 60 seconds and *separately* etching the films in 20% HNO_3 for 10 minutes. *Id.* The only concentration for *simultaneous* HF/HNO_3 etching taught in Seraphin is a solution of 2% HF, 48% HNO_3, and 50% H_2O. *Id.* Seraphin does not suggest modifying its solution by adjusting the amount of HF and HNO_3 to the claimed range. *Id.* Thus, Seraphin fails to even teach or suggest etching silicon *thin films* in a solution that includes 0.5% to 20% HF and about 10% to 40% HNO_3, let alone etching free silicon nanoparticles with such a solution, as required by claim 28.

Secondly, the etch rate of claim 29 is neither taught nor suggested by Seraphin. As noted above, Seraphin teaches use of a mixture of 2% HF, 48% HNO_3, and 50% H_2O for acid etching via simultaneous exposure to HF and HNO_3. 2d Swihart Decl. ¶ 10. The shift in photoluminescence using this mixture is achieved with an exposure time of 10 seconds. *Id.* Such short exposure times are not practical for free particles. *Id.* For the longer exposure times shown (*i.e.*, 30 and 60 seconds), there is little additional blue-shift of the photoluminescence, and the primary effect is simply a reduction in photoluminescence intensity, which is undesirable. *Id.* Therefore, one of ordinary skill in the art would have concluded that it would be ill-advised to etch with this mixture for longer periods. *Id.* Not only does Seraphin fail to teach or suggest etching silicon nanoparticles (agglomerated or free) in a solution containing HF and HNO_3 for two to thirty minutes, as required by claim 29, it in fact teaches away from doing so.

Finally, it would not have been obvious to one of ordinary skill in the art how to modify the methods of Seraphin to achieve the present invention. As described in the present application, tuning of the photoluminescence wavelength for free silicon nanoparticles using a HF/HNO_3 solution is only practical when the HNO_3 concentration is reduced or the etching solution is otherwise modified to make the etching process substantially slower than the process taught by Seraphin. 2d Swihart Decl. ¶ 11. Seraphin does not suggest how to modify its method to make it suitable for free silicon nanoparticles, and doing so would not have been obvious to one of ordinary skill in the art. *Id.*

As for claims 31–34, Seraphin does not teach or suggest the claimed process for producing free silicon nanoparticles having stable photoluminescence.

Seraphin reports treating agglomerated particles with HNO_3 to produce a surface oxide layer on the particles. 2d Swihart Decl. ¶ 12. However, Seraphin does not

create the oxide layer to stabilize the photoluminescence of the particles. *Id.* Instead, Seraphin produces the oxide layer for the sole purpose of reducing the size of the crystalline silicon core of the particles. *Id.* The oxide layer is immediately removed by a subsequent exposure to HF, in order to further reduce the particle size. *Id.* Thus, while Seraphin teaches the formation of an oxide layer by exposure to HNO_3, Seraphin does not teach the use of this process to stabilize the photoluminescence. *Id.* In contrast, Seraphin considers "aging" and HNO_3 treatment to be equivalent means of reducing the size of the silicon core. *Id.* Therefore, Seraphin does not even teach treating silicon *thin films* with a chemical oxidizer to stabilize photoluminescence, let alone to do so with free silicon nanoparticles. *Id.*

Not only is the claimed method not taught in Seraphin, it would not have been obvious to one of ordinary skill in the art. The only discussion in Seraphin relating to the stability of photoluminescence is in relation to silicon nanoparticle thin films that are oxidized in air. 2d Swihart Decl. ¶ 13. The photoluminescent peak reportedly remains at a final position after three days of aging, but no data beyond three days is given. *Id.* Moreover, while Seraphin addresses the stabilization of photoluminescence wavelength, it does not say anything about the photoluminescence intensity. *Id.* In contrast, the present application demonstrates that chemically formed oxide produced, *e.g.*, by HNO_3 treatment provides much greater stabilization of the photoluminescence of free silicon nanoparticles than the "native" oxide that is formed by exposure to room air. *Id.* In particular, the present application shows that treating silicon nanoparticles with a chemical oxidizer not only stabilizes the photoluminescence wavelength, but also the intensity. *Id.* Prior to the work described in the present application, it was not known, and there was no reason to expect, that treatment with a chemical oxidizer (*e.g.*, HNO_3) would have provided a more protective oxide shell than oxidation in air or other oxidative treatment. *Id.*

For these reasons, Seraphin fails to teach or suggest a process for producing free silicon nanoparticles having stable photoluminescence by treating free silicon nanoparticles which are photoluminescent with a chemical oxidizer under conditions effective to achieve particle surface oxidation, thereby stabilizing the photoluminescence of the free silicon nanoparticles, as required by claims 31–34 of the present invention.

For all of these reasons, the rejection of claims 28–34 for obviousness over Seraphin is improper and should be withdrawn.

In view of all of the foregoing, it is submitted that this case is in condition for allowance and such allowance is earnestly solicited.

Respectfully submitted,

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